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Research Article

# Comparison of Charging and Usage Efficiency of Portable Fan Batteries Between PLN Electricity and Solar Panels at Different Times

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**Abstract:** *The provision of sufficient energy to meet human needs is severely hampered due to the lack of energy sources. Solar panels as one of the tools to design alternative power plants that can be used to capture sunlight and can be an alternative to energy sources. This research aims to provide a clear picture of the efficiency of using solar panels as an alternative energy source when compared to PLN's electrical energy source, as well as to identify the fastest time to use solar panels and the most effective time to charge using solar panels. In this study, a comparative experimental method was carried out, namely solar panels placed in the sun with different time conditions, namely in the morning, afternoon, and evening. The time obtained in the three conditions is 5400 s, 14400 s, 16200 s, and the average time of charging using PLN is 7574.6 s. The results obtained by this study include charging portable batteries more effectively on solar panels than on PLN, and maximum charging during the day.*

**Keywords:** Electricity, Solar Panel, Lithium Battery

## 1. Introduction

In this modern era, the demand for energy continues to rise along with population growth and technological development. This has also increased the demand for the internet, electricity charging, and access to information [1]. However, primary energy sources such as petroleum and coal are expected to deplete and eventually run out [2]. The use of these primary energy sources not only faces the issue of scarcity but also significantly contributes to global warming and climate change. The greenhouse gas emissions from burning fossil fuels have led to an increase in global average temperatures, impacting various aspects of life, including rising sea levels, changes in weather patterns, and an increased frequency of natural disasters [3].

The shortage of these energy sources presents a serious challenge in providing enough energy to meet human needs. Therefore, governments and non-governmental organizations, both nationally and internationally, are working to popularize Renewable Energy (RE) as an alternative to fossil fuels. One potential RE source is solar energy [4]. This energy is available in large quantities, non-polluting, and will not run out even if used for free [5]. If solar energy can be effectively utilized, it could reduce the use of electricity from the PLN (National Electric

Company), especially during the current energy crisis [6]. Solar panel technology or solar cells is one way to harness solar energy and convert it into electricity [4].

A relevant study was conducted by Ariawan, who designed and tested a portable mobile phone charger based on solar panels using literature study, circuit testing, and data analysis methods. The design process involved creating a block diagram, mechanical design, and circuit assembly. Testing was done in two phases: testing the solar panel for three days and testing the battery charging time with various loads. The results showed that the intensity of sunlight greatly affects the solar panel’s output voltage, with the highest intensity at 12:00 PM. However, this sunlight intensity did not affect the current on the solar panel itself [7].

Another relevant study by Nurba et al. used a design and testing method for a portable battery charging system based on solar panels. They designed the system using a 20Wp solar panel, a buck step-down converter, and a buck CC/CV converter. Testing was done in stages, including testing individual components such as the XL4015 module, testing the solar panel for 3 days to measure light intensity and output voltage, testing the charging of lithium polymer batteries, and testing the entire system, including mobile phone battery charging time. The results showed that the sunlight intensity greatly influenced the output voltage of the solar panel. Maximum intensity was obtained between 10:00 AM and 2:00 PM in sunny conditions and was minimal when the sunlight decreased/when it was cloudy [8].

In a study by Sudarti, light intensity measurements were conducted using a smart luxmeter Android application in a 3x3 meter room with a 3-watt LED light. The measurements were made at four corners of the room, 2 meters away from the light source. The results showed that the average measured light intensity was 12.25 Lux, far below the SNI 16-7062-2004 standard, which recommends a minimum of 120 Lux for workspaces. The application proved to be efficient for measuring and collecting light intensity data [9].

This study takes a step forward by examining the use of solar panels as an alternative for charging portable fan batteries, a concept that has not been widely explored, thus opening opportunities for further exploration in this field. This is evident in the research by Zauzi et al., which focuses on designing a wireless portable charging system with solar panels for charging mobile phone batteries but does not discuss its application for portable fans [10]. Meanwhile, a study by Purwoto discusses the efficiency of using solar panels as an alternative energy source compared to generators, but does not specifically examine their application on portable fans [11].

Leveraging Indonesia's favorable geographic conditions, this study aims to test the effectiveness of solar panels compared to conventional electricity sources from PLN in charging portable fan batteries. This research will also evaluate the efficiency of battery charging at different times: morning, afternoon, and evening, under sunny conditions for all three times, with the help of the Smartlux Android-based app, offering a new perspective in measuring light intensity.

## 2. Materials and methods

The method used in this study is a comparative experimental approach. This research was conducted to compare the charging efficiency of the lithium 18650 battery between two different power sources. The initial experiment used the PLN (state electricity company) grid, similar to a typical charging process with the help of a micro USB cable. The subsequent experiment used two mini solar panels as the power source to charge the battery, and the charging efficiency was evaluated at different times of day (morning, afternoon, and evening).


**Figure 1.** Tools and Materials

The researcher designed a circuit for charging the lithium 18650 battery, which consists of two mini solar panels, a TP4056 battery charger module, a 6-15 V micro buzzer, a battery level indicator, a PNP transistor A1015, a lithium 18650 battery with a single battery holder, and a 1K Ohm resistor. This circuit was modified so that when the battery is fully charged, the buzzer will emit an alarm, and the battery level indicator will display the charging status (25%, 50%, 75%, and 100%).


**Figure 2.** Battery Charger Module Circuit Diagram

The initial step in creating the battery charger module circuit involves several components, including a TP4056 battery charger, a 1 K Ohm resistor, a lithium 18650 battery holder, a PNP transistor A1045, and a battery level indicator. First, solder the lithium 18650 battery holder to the output, ensuring both the positive and negative terminals are connected. The PNP transistor A1045 has three pins: collector, base, and emitter. Solder the collector pin of the A1045 transistor to the input of the TP4056 charger module. Then, solder the 1 K Ohm resistor to the base pin of the A1045 transistor. Finally, solder the emitter pin of the A1045 transistor to the positive wire of the buzzer, while the negative wire of the buzzer is connected to the input of the TP4056 charger module. Test the circuit by placing the lithium 18650 battery into its holder. Then, use a micro USB cable to connect the circuit to the PLN electricity supply. Ensure the battery indicator lights up before proceeding to the next step.

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**Figure 3.** Solar Panel Box Diagram

The second step is to create the solar panel box. First, solder the positive and negative terminals of the solar panels to wires. Place the two solar panels, with the soldered wires, on a sheet of duplex paper, and draw lines with a pencil according to the size of the panels. Then, cut the duplex paper following the drawn lines. Create four small circles on the cut duplex paper, the size of each solar panel, to insert each solar panel's wire. For the four circular patterns, use the tip of scissors to make holes. Insert the solar panel wires into the holes, then solder the wires according to their polarity. Flip the duplex paper over and secure the wires with black tape to ensure the solar panels stay in place and don't fall off. The top of the solar panels can be covered with rolled mica film to protect them from water or other objects. The duplex paper is divided into four sections to create partitions for the solar panel box and the circuit. The battery charger module is placed inside the box along with the back wires of the solar panels. Add the red and black wires, then connect them to the battery module circuit as the input. Afterward, secure the wires with black tape to keep the circuit neat and prevent it from falling when the box is flipped. To close the box, create a partition and lid with appropriate dimensions.


**Figure 4.** Charging the Lithium 18650 Battery Using PLN Power Source

The first experiment uses a charger module circuit to charge the lithium 18650 battery with a PLN power source. The first step is to open the solar panel box cover. Then, connect the micro USB cable from the battery charger module to the PLN power source. Start the stopwatch when the indicator light turns on, signaling that the charging process has begun. When the battery level

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indicator shows that the battery is full, stop the stopwatch, indicating that the charging process is complete. After the charging process is finished, the lithium battery can be used, for example, to power the portable fan.


**Figure 5.** Charging the Lithium 18650 Battery Using Solar Energy Source

The second experiment uses a charger module circuit to charge the lithium 18650 battery with a solar energy source. The first step is to ensure that the solar panel box is covered with the partitions that were made. Then, flip the box so that the solar panels are on top. Next, go outdoors at three different times (morning, afternoon, and evening) and place the box under direct sunlight with no obstructions. Start the stopwatch when the indicator light turns on, signaling that the charging process has begun. Use a light meter app to measure the light intensity during charging, whether in the morning, afternoon, or evening. When the battery level indicator shows that the battery is full, stop the stopwatch, indicating the charging process is complete. After the charging process is finished, the lithium battery can be used, for example, to power the portable fan.

The data sources include direct observation during the battery charging and usage phases, which were used in the portable fan. The research variables for the "Comparison of Charging and Usage Efficiency of Portable Fan Batteries Between PLN Electricity and Solar Panels at Different Times" are as follows:

1. The time required to charge the lithium 18650 battery using PLN electricity and solar panels at different times of day (morning, afternoon, and evening).
2. A comparison of the lithium 18650 battery usage duration in the portable fan after charging with either PLN electricity or solar panels.
3. The use of an Android app called "Light Meter" to measure the intensity of light at specific times (for solar-powered charging).

## 3. Results and discussion

**Table 1.** Battery Charging and Usage of Portable Fan Battery Using PLN Power Source

| No. | Battery Charging Time (s) | Portable Fan Usage Time (s) |
| --- | --- | --- |
| 1. | 5400 | 10800 |
| 2. | 14400 | 7440 |
| 3. | 16200 | 10800 |
| $\bar{x}$ | 12000 | 9680 |

**Table 2.** Battery Charging and Usage of Portable Fan Battery Using Solar Panel

| No. | Average Intensity (lux) | Time/Hour | Battery Charging Duration (s) | Portable Fan Usage Duration (s) |
| --- | --- | --- | --- | --- |
| 1. | 39793 | 14.30—16.00 | 7206 | 7200 |
| 2. | 238753 | 11.00—13.00 | 5654 | 5400 |
| 3. | 21413 | 09.00—11.45 | 9864 | 8100 |
| $\bar{x}$ | 99986,33 | - | 7574,6 | 6900 |

The energy needs of living organisms are an area of continuous development [12]. The biggest challenge faced by humans is the shortage of energy sources, which is why the creation of this simple solar panel is conducted to study the efficiency of sunlight for life, especially for electronic devices. In this study, the researcher uses a portable fan as an example of an electronic device for charging the fan's voltage battery. The researcher uses a simple solar panel to charge the portable fan's battery voltage. The research objectives will be answered based on the data collected during the experiments.

In this context, the use of solar panels is expected to provide an alternative for humans to charge electronic devices. Over time, energy sources like coal and others will run out [13], which is why research on renewable energy continues to be a solution for generating new data for scientific knowledge. The experiment using PLN electricity to charge the portable fan's voltage battery showed an average charging time of 3.9 hours.

Based on Tables 1 and 2, there are differences in the charging and battery usage times of the portable fan. Charging the battery using PLN electricity resulted in an average charging time of 12,000 seconds or 3.3 hours, while charging with solar panels required an average of 7,574.6 seconds or 2.1 hours. Based on this data, the use of solar panels to charge the battery is more efficient than using PLN electricity. Faster charging time helps improve time efficiency. The battery usage time of the portable fan was not much different: 9,680 seconds or 2.7 hours for the battery charged with PLN electricity, and 6,900 seconds or 1.9 hours.

The experiment using solar panels to charge the battery was conducted at different times to compare the most efficient times for charging the battery under sunlight. Based on Table 2, the charging time between 11:00 AM to 1:00 PM was faster than charging between 2:30 PM to 4:00 PM and 9:00 AM to 11:45 AM. The charging times in order of speed are 11:00 AM to 1:00 PM (daytime), 2:30 PM to 4:00 PM (evening), and 9:00 AM to 11:45 AM (morning). This aligns with the theory that the more intense the sunlight, the faster the battery charging [14].


**Figure 6.** Results of light intensity measurement during the day.

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**Figure 7.** Results of light intensity measurement in the evening.

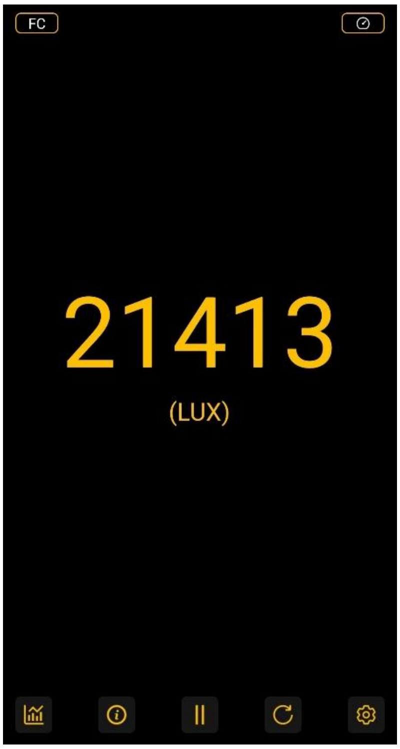


**Figure 8.** Results of light intensity measurement in the morning.

The use of the Android-based Smart Luxmeter application is employed to compare light intensity during the day, evening, and morning. This application utilizes the light sensor found in smartphones to measure the intensity of the surrounding light. In addition to providing real-time readings, the Smart Luxmeter app also features a user-friendly interface, making it easy to operate and record data [9]. The light dispersion measured is direct, meaning it is measured directly under the sunlight [9]. This is done to ensure more accurate data. Based on Table 2, the results show the light intensity from highest to lowest as follows: daytime with an intensity of 238,753 lux, evening with an intensity of 39,793 lux, and morning with an intensity of 21,413 lux. This is consistent with the theory that the higher the intensity, the faster the battery charging [15].

## 4. Conclusion

Based on the research findings, there is a difference in the duration of charging a portable fan battery using solar power (sunlight) and electricity from the PLN (state electricity company). This is evident from the variation in the charging times, where charging using solar power is faster compared to using electricity from the PLN. Therefore, the effectiveness of the solar panel is higher than the conventional electricity source from PLN in charging the portable fan battery. However, the most effective time for charging using solar panels is during the day, as the charging time during the day is significantly faster compared to other times, such as morning and evening. This happens because the intensity of sunlight during the day is much higher than in the morning and evening. Therefore, it can be concluded that using solar power to charge a portable fan battery is best done during the day, or when the sun is high in the sky, to ensure faster charging.

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